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ABSTRACT

An experiment apparatus tested two hypotheses: a) supplementary feedback aids learning when it provides information by which to distinguish long target contacts from short ones; b) supplementary feedback, especially if immediate, facilitates performance by providing secondary reinforcement. Five groups, of 20 subjects each, were given 60 trials, with the criterion interval adjusted for every trial to reinforce a particular proportion of target contacts for each group: 100 percent (immediate buzzer), 89 percent, 50 percent, 11 percent, and 0 percent (no buzzer). Analysis of convariance indicated that the buzzer significantly improved performance, with the best performance shown by the groups that had an immediate proportion of the hits reinforced. Information theory would explain some of the results, but would not account for all of the group differences found. (Author)

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Elmo E. Miller, Richard W. Sheldon, and John F. Bjorklund

HumRRO Division No. 2 (Armor)

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FOREWORD

The objective of Basic Research Study 9, Learning of Skills, is to produce and sustain high performance levels, in both individual and group tasks, by specifying standards of performance and reinforcing closer and closer approximations of these standards. The project is an outgrowth of a series of studies from FIREPOWER IV in which feedback conditions were varied to show the effects on target detection performance.

BR-9 research is being conducted at HumRRO Division No. 2 (Armor). Dr. Norman Willard, Jr., was Director of Research during the study reported here, and Dr. Donald F. Haggard is the present Director of Research. Support is provided by the U.S. Army Armor Human Research Unit. COL George H. Spires was Chief of the Unit during the early phases and COL Walter J. Davies during the later phases of the work described in this report.

This report is a summary of a study made to test two hypotheses: (1) that supplementary feedback aids learning when it provides information by which to distinguish long target contacts from short ones; and (2) that supplementary feedback (especially if immediate) facilitates performance by providing reinforcement.

Two other studies have been reported: Pursuit Rotor Performance: 1. Effects of Reinforcing the Longer Intervals of Continuous Tracking Within Each Trial, HumRRO Technical Report 66-11 (1); Pursuit Rotor Performance: 2. Effects of Reinforcing Successively Longer Intervals of Continuous Tracking Over Practice Sessions, HumRRO Technical Report 66-22 (2). Earlier work on the project was described in two journal articles: "The Use of Schedules of Reinforcement to Regulate a Collective Team Response Rate," by Peter C. Wolff, David D. Burnstein, and L. Dennis Cannon, Psychological Record, vol. 14, no. 1, January 1964; "Shaping of Three-Man Teams on a Multiple DRL-DRH Schedule Using Collective Reinforcement," by D.D. Burnstein and P.C. Wolff, Journal of the Experimental Analysis of Behavior, vol. 7, no. 2, March 1964.

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Meredith P. Crawford
Director
Human Resources Research Office

SUMMARY AND CONCLUSIONS

Problem

In practice on tracking in research on psychomotor performance, the usual visual display on laboratory apparatus may be supplemented by an auditory reinforcing stimulus presented when the subject is "on target," or when he stays on target for a specified interval or longer. Conceivably such a signal helps him by stressing his relatively long, skillful target contacts, as distinguished from momentary contacts. Past experiments concerned with this type of supplementary feedback have been ambiguous, and their interpretation is still debated.

In the present study, information theory was used to explain the general pattern of past results. An experiment was designed to test two hypotheses: (1) that supplementary feedback aids learning when it provides the subject with information (as defined by information theory) to distinguish his long target contacts from his short ones, and (2) that supplementary feedback has secondary reinforcing value, so that it would facilitate performance, especially when it is provided as soon as the subject touches the target.

Method

Five groups, of 20 men per group, were given 60 trials on the pursuit rotor. The criterion interval (interval of continuous contact required to activate a buzzer) was adjusted for every trial in order to reinforce a particular proportion of hits for each treatment group, as follows: 100% (immediate buzzer), 89%, 50%, 11%, and 0% (no buzzer). The criterion interval setting on any trial was accomplished for the treatment group by considering the subject's performance on the previous trial, and the normative data in a preliminary experiment.

Results

The principal results of the study are:

(1) The best performance was shown by those groups that had an intermediate proportion of the hits reinforced, in accord with the information theory explanation.

(2) Better performance resulted from reinforcing all, or almost all, of the hits than from reinforcing only a few of the hits.

(3) There were some statistically significant differences in performances by the experimental groups, but not in a simple pattern, over all.

Conclusion

Although the general pattern of results seems to reflect the influence of the factor described by the information theory explanation, the details are not sufficiently clear to warrant firm conclusions, and this factor does not account for all the group differences found.

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Supplementary Feedback: An Explanation and Experimental Test

INTRODUCTION

In practice on tracking in research on psychomotor performance, the usual visual display for pursuit rotor or similar laboratory apparatus may be supplemented by an auditory stimulus, presented as a reinforcement when the subject is on target or when he stays on target for a specified interval or longer. Thus, if he must stay on target for .5 second to hear a tone, then the tone may serve to distinguish, or to emphasize, the longer target contacts. Such a tone would be a poor substitute for vision, but it may help the subject by establishing a criterion for judging quality of performance; it will therefore be called supplementary feedback.

Sometimes supplementary feedback is called delayed feedback, but the term delay might be used more appropriately in situations where there is a lag, or a simple time lapse, between response and feedback function. Thus, if there were a .5-second feedback lag (or delay), then the feedback at any instant is simply determined by whether there was target contact .5 second before; therefore, every target contact generates a feedback signal .5 second later, even if contact is lost in the meantime. But with supplementary feedback as we define it, the feedback signal is contingent upon continuous contact over the specified interval, so that the shorter contacts will never generate an auditory signal.

Supplementary feedback has been the subject of several experiments, but the results and explanations are still debated. Reynolds and Adams (3), using the pursuit rotor, gave a click reinforcement at various criterion intervals of target contact (from immediate click to a click for two seconds of continuous contact), and found that a .5-second criterion seemed optimal. Archer, Kent, and Mote (4), using a somewhat more difficult aiming task, presented a tone after various intervals of continuous contact, but found no evidence for the effectiveness of the supplementary feedback. Later, Archer and Namikas (5), using a pursuit rotor, also failed to confirm the effectiveness of supplementary feedback in improving tracking.

Bilodeau and Rosenquist (6) suspected that the differences might be due to the kind of supplementary feedback employed; for one group, they presented a momentary sound (as did Reynolds and Adams), and for another group they presented a continuous sound as long as the subject stayed on target beyond a .5-second criterion (as did Archer and Namikas). They found no significant differences between these experimental groups, or between either group and a control group that received no supplementary feedback. In an earlier study in the present research program, Sheldon and Bjorklund (1), using the pursuit rotor, obtained data that seem to support results of the Reynolds and Adams study.

Perhaps the conflict might be resolved if the potential advantage of supplementary feedback could be defined exactly. Reynolds and Adams (3) suggest that it is a matter of setting the criterion interval to help the subject distinguish his momentary target contacts from his longer and therefore more skillful contacts. Thus this kind of supplementary feedback might be an exception to the general rule, that transformations of knowledge of results generally have little effect when the target itself is sharp and clear (7, 8, 9, 10).

Without supplementary feedback, the subject may be only vaguely aware of the duration of each target contact, especially as each contact compares with his general level of skill at that time. Supplementary feedback may give him categorical (qualitative) information about his target contacts, by sharply dividing them into good and bad.

Information theory (or test construction theory) seems especially suitable for defining the best criterion interval, according to the function of distinguishing good and bad contacts. The maximum information is provided if one-half the contacts are within the criterion interval. Also, the subject should expect that good contacts and bad contacts are equally likely to occur. In terms of test construction theory, such a dichotomy results in the greatest number of distinctions between good and bad contacts. Formulas are available for determining the amount of information provided when other percentages of contacts exceed the criterion interval (11).

The criterion interval should be adjusted to each man at each level of skill during training, because the information value of a reinforcement (or absence of reinforcement) depends in part on the likelihood of a reinforcement at that particular moment. The idea of adjusting to a subject's skill level is closely related to the idea of shaping, defined as reinforcing successive approximations of the desired response. In the present instance, however, it is length of contact that defines the degree of approximation, and a specific percent of reinforcement is postulated.

In experiments on supplementary feedback, the proportion of contacts reinforced is not customarily reported or recorded; however, rough estimates can be made from data such as those of Namikas and Archer (12), who recorded the distribution of target contacts by the length of contact. Under these experimental conditions the median length of contact (Trials 21-25, about 30% of the time on target) was in the interval of .10 - .19 second. The conditions were somewhat more difficult than those used by Reynolds and Adams, whose target was almost two inches closer to center, so that its linear speed was only 63% as great (13). The less difficult conditions of Reynolds and Adams are reflected in greater average time-on-target scores, which improved from about 45% on the fifth trial to about 65% on the 65th trial. It seems reasonable to suppose that, in their study, the .5-second criterion interval condition was the one that most nearly approximated the theoretical optimum (according to the proposed explanation), 50% of contacts reinforced, and that the other conditions resulted in substantially less information from the clicks. (The latencies used were .1, .2, .5, 1.0, and 2.0 seconds, and no buzzer.)

Although Reynolds and Adams had expected the longer criterion intervals to be optimal in later stages of training, such a prediction seems unwarranted for that study because of the small change in scores within the experiment, and the gross differences between the groups in the criterion intervals employed.

Similarly, the study by Archer, Kent, and Mote (4) involved such a difficult task that the subject was rarely reinforced for a hit. In the study by Archer and Namikas (5), a pursuit rotor was used but under somewhat more difficult conditions than those of Reynolds and Adams (3); .2 second would therefore be expected to be about the optimal latency, if the information explanation is correct. The Archer and Namikas .2-second latency group performed the best, although the differences were not statistically significant. However, they used fewer subjects than did Reynolds and Adams, so differences would be harder to detect.

An information theory explanation, then, seems generally consistent with the pattern of results obtained in past research on supplementary feedback. The present study is an attempt to test the explanation with further data.

The information explanation leads to a different way of managing the independent variable. Instead of having various absolute criterion intervals for the various experimental groups, an attempt was made to approximate different percentages of reinforcement for the experimental groups. Thus, at the extremes, 100% of the hits were reinforced (by sounding the buzzer when the subject was on target), or 0% of the hits (by turning off the buzzer completely). Between these extremes, various levels of reinforcement were chosen (89%, 50%, and 11%), and for each subject in these groups, the criterion (contact time) interval was varied from trial to trial in an attempt to approximate the desired level of reinforcement.

Another possible influence should be mentioned: On the basis of general psychological theory, other kinds of effects might be expected from supplementary feedback, although such effects are not readily apparent in the experiments so far. The supplementary feedback stimulus might be expected to be a secondary reinforcer, from its association with a pleasurable state when the subject is on target. The best performance would therefore logically be expected if the subject hears a sound whenever he is on target, while progressively worse performance would be expected as the criterion interval is lengthened, as a result of two circumstances: (a) with longer criterion intervals, secondary reinforcement is less frequent; and (b) with longer criterion intervals, there is more time between the initial target contact and the occurrence of secondary reinforcement.

METHOD

Subjects

One hundred men from a pool of subjects comprised of enlisted men were assigned to five groups, with 20 men in each group. The first five men to appear were distributed randomly, by drawing lots to five conditions; each subsequent five men were similarly distributed. Two men from different groups were given the experimental trials together, alternating practice and rest periods. Any man who did not achieve five seconds total time-on-target (TOT) on at least one of ten pre-trials (during which all men were treated alike) was eliminated, and replaced by the next to appear. (Ten subjects, distributed unsystematically among groups, failed to meet the 5-second criterion.)

Apparatus

The subjects tracked a .75-inch aluminum target (Figure 1) which revolved at 60 rpm on a 3.25-inch orbit. The stylus used was a 1/8-inch brass rod, hinged 4.5 inches from the bent tip, with a handle shaped to fit the hand. There was a buzzer of moderate intensity which would begin

Pursuit Rotor

Figure 1

sounding after a specific duration on target; the experimenter (in another room) could adjust the buzzer to any criterion interval by setting a dial. For recording the data, there were counters for number of contacts and number of times the buzzer sounded, and an electric timer that recorded time-on-target (TOT) to the hundredth of a second.

Task

Each subject was given 10 pretrials, 3 blocks of experimental trials (15 trials per block), and 5 posttrials. The trials were 30 seconds long, with 30-second rests between trials, and longer rest periods between blocks of trials while the other subject was run. Before the experiment was begun, every man heard standard memorized directions (Appendix A) spoken by the same experimenter.

During the 10 pretrials, all men were treated alike; that is, no buzzer sounded. (These 10 pretrials were used for a covariance adjustment of scores.) Just before the blocks of experimental trials were begun, the subject heard instructions (Appendix B) pertaining to his particular group. A buzzer was operative for the three blocks of experimental trials (for all groups except the control group, which never heard a buzzer).

The experimental conditions for the five groups differed in the approximate percent of target contacts which were to be reinforced, as follows: 100% (immediate buzzer); 89%; 50%; 11%; and 0% (no buzzer). These five conditions gave the subject varying amounts of auditory information for deciding which were his longer hits. Thus, the 0% and 100% groups were given no information, beyond what was available by direct vision. The 50% group was given an average of one bit of information per contact; and the 89% and 11% groups, an average of .5 bit of information per contact (11).

For each condition, the approximate proportion of reinforcements was achieved by varying the criterion interval, defined as the interval of continuous target contact required to activate the buzzer. For the 11%, 50%, and 89% groups, the criterion interval was adjusted on each trial, on the basis of (a) the group to which a man was assigned, and (b) his performance on the preceding trial. Preliminary experimentation provided data for estimating what criterion interval would produce each desired percent of reinforcement.

For a few subjects in the delayed buzzer groups (89% group, 4; 50% group, 3; 11% group, 3), the experimenter guessed at the interval settings, to achieve percentage of reinforcement over the desired range. For each trial with supplementary feedback, the ratio of criterion interval setting to mean length of contact was computed and plotted on graph paper against the percent of hits actually reinforced. A curve was fit by visual estimation and used to determine, from TOT and number of hits on the previous trial, what criterion interval would produce the desired percent of reinforcement on the coming trial. This procedure assumes that the buzzer latency can be adjusted to a constant fraction of the mean length of contact. The result will be to reinforce a constant percentage of hits (approximately), regardless of the skill level and the variability of the subjects; the assumption appears warranted, because the pattern did not change noticeably when only high TOTs were plotted, or when each subject's data were plotted separately.

Before the experiment, the criterion intervals were calculated for each TOT and for any number of hits, and put onto large charts, so that the experimenter could readily make the necessary setting between trials. Before the five posttrials, the men were apprised of the fact they would get no more buzzer.

RESULTS AND DISCUSSION

During the 10 pretrials (before differential treatment was introduced), the groups did not differ significantly; in fact, the between variance was significantly smaller than the within variance ($p < .05$). This close matching of groups may be a result of distributing successive groups of five among the conditions, which might result in an overconservative test. The supplementary feedback approximated the desired proportions, as shown in Table 1.

Table 1

Proportion of Hits Reinforced

Group	Mean	Range of Individual Subject's Means
89%	.91	.86–.93
50%	.47	.40–.50
11%	.14	.11–.16

After the buzzer was introduced on Trial 11, a pattern of means appeared, (Table 2), but the differences are not quite significant statistically. However, the same general pattern appears when the results are analyzed by means of adjusted scores (covariance adjustment).

Since all groups were treated alike for the 10 trials, these trials provide a basis for adjusting each man's scores for the three blocks of experimental trials (14, pp. 606-618). Using adjusted scores is appropriate because the performances on the 10 pretrials (Trials 1-10) were not used in assigning men to groups and therefore should be independent of the group. The general pattern of mean adjusted scores is shown in Table 3 (see also Figure 2). The average "adjusted" score for any block of trials with differential buzzer conditions (Table 4) shows significant differences among groups at the .05 level or beyond. (These "F" tests merely indicate significant variation among the treatment groups, but further tests are needed to determine which particular means are significantly different. The significant differences among means can be analyzed by applying the hypotheses outlined above.)

Table 2

Mean Time-on-Target for the Five Groups for the Blocks of Trials
(in Seconds)

Group	Trial Block				
	11-25	26-40	41-55	11-55	56-60
100%	14.7	17.3	18.1	16.7	19.3
89%	14.1	17.8	19.2	17.1	20.2
50%	14.6	17.6	18.7	17.0	18.6
11%	13.3	15.9	17.4	15.5	18.5
0%	13.1	15.0	16.3	14.8	17.6

Table 3

Mean Adjusted Scores for the Five Groups for the Blocks of Trials [a]
(in Seconds per Trial)

Group	Trial Block				
	11-25	26-40	41-55	11-55	56-60
100%	14.7	17.3	18.2	16.7	19.3
89%	14.5	18.2	19.6	17.4	20.5
50%	14.5	17.5	18.6	16.8	18.5
11%	12.9	15.6	17.1	15.2	18.2
0%	13.2	15.1	16.4	14.9	17.6

[a] Adjusted for correlation with mean performance on the pretrials—Trials 1-10.

Some of the differences in performance among groups may persist after the buzzer is withdrawn, although the significance does not quite reach the .05 level. In any case, the change in performance on the posttrials (Trials 56-60) is not significant when compared with performance on the third block of trials (Trials 41-55). Thus, there is some doubt about whether performance differences caused by buzzer conditions are retained when the buzzer is turned off.

Table 4

Significance of Average Adjusted Scores

Trials	*F*	*p*
11-55	4.67	<.01
11-25	3.88	<.01
26-40	5.55	<.001
41-55	3.47	<.05
56-60	2.26	<.10

Average "Adjusted" Time-on-Target for the Five Experimental Conditions, as a Function of the Proportion of Target Contacts Reinforced

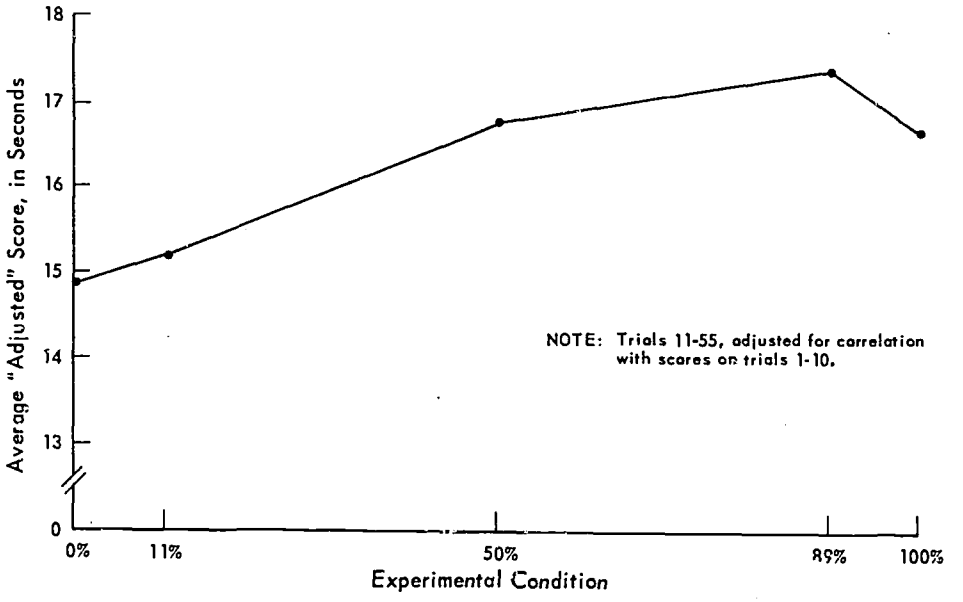

Figure 2

Concerning the hypotheses being considered, the group means (Figure 2) are patterned as if the results were determined by the sum of two tendencies:

(1) The buzzer is most effective if it is activated after an optimal criterion interval (as defined by the first hypothesis, applying information theory).

(2) The buzzer facilitates performance, and the shorter the criterion interval, the better the performance (as consonant with the second hypothesis, involving secondary reinforcement).

Table 5

Results of Duncan's Multiple Range Test for Adjusted Means on Trials 11-55[a]

Level	Relationship Between Group Scores[b]					Mean Differences for Significance[c]		
	0% 14.89	11% 15.19	100% 16.72	50% 16.85	89% 17.46	Rank	$p<$ .05	$p<$ .01
.05	———	———				2	1.46	1.94
		———	———			3	1.54	2.03
			———	———		4	1.59	2.08
				———	———	5	1.62	2.12
.01	- - - - - - - - - - -							
		- - - - - - - - - - -						
			- - - - - - - - - - -					
				- - - - - - - - - - -				

[a] Adjusted for Trials 1-10 mean.

[b] Those means connected by a common line segment are *not* significantly different.

[c] The values shown, calculated from the data, are the mean differences needed to reach significance, at the .05 and the .01 level, for means that are one, two, three, and four ranks apart respectively.

Table 6

Results of Duncan's Multiple Range Test for Adjusted Means on Trials 11-25[a]

Level	Relationship Between Group Scores[b]					Mean Differences for Significance[c]		
	11% 12.90	0% 13.18	50% 14.51	89% 14.54	100% 14.69	Rank	$p<$ .05	$p<$ .01
.05	———	———				2	1.22	1.62
		———	———			3	1.29	1.69
			———	———		4	1.33	1.74
				———	———	5	1.36	1.78
.01	- - - - - - - - - - -							
		- - - - - - - - - - -						
			- - - - - - - - - - -					
				- - - - - - - - - - -				

[a] Adjusted for Trials 1-10 mean.

[b] Those means connected by a common line segment are *not* significantly different.

[c] The values shown, calculated from the data, are the mean differences needed to reach significance, at the .05 and the .01 level, for means that are one, two, three, and four ranks apart respectively.

Table 7

Results of Duncan's Multiple Range Test for Adjusted Means on Trials 26-40[a]

Level	Relationship Between Group Scores[b]					Mean Differences for Significance[c]		
	0% 15.10	11% 15.59	100% 17.30	50% 17.47	89% 18.19	Rank	$p <$ .05	$p <$ .01
.05	———		———			2	1.58	2.11
						3	1.67	2.20
						4	1.72	2.26
						5	1.76	2.30
.01		- - - - - - - -						
	- - - - -							

[a]Adjusted for Trials 1-10 mean.

[b]Those means connected by a common line segment are *not* significantly different.

[c]The values shown, calculated from the data, are the mean differences needed to reach significance, at the .05 and the .01 level, for means that are one, two, three, and four ranks apart respectively.

Table 8

Results of Duncan's Multiple Range Test for Adjusted Means on Trials 41-55[a]

Level	Relationship Between Group Scores[b]					Mean Differences for Significance[c]		
	0% 16.40	11% 17.08	100% 18.16	50% 18.56	89% 19.65	Rank	$p <$ .05	$p <$ .01
.05	———					2	1.93	2.57
						3	2.03	2.68
						4	2.10	2.75
						5	2.14	2.80
.01	• • • • • • • • • • • •							
	o o o o o o o o o o o o							

[a]Adjusted for Trials 1-10 mean.

[b]Those means connected by a common line segment are *not* significantly different.

[c]The values shown, calculated from the data, are the mean differences needed to reach significance, at the .05 and the .01 level, for means that are one, two, three, and four ranks apart respectively.

Clearly, the first hypothesis—applying information theory—does not in itself account for the results. As shown in Tables 5, 6, 7, and 8, the 100% (immediate buzzer) group performed significantly better than either the 0% (no buzzer) or the 11% (long criterion interval for buzzer) groups.[1] These results are consistent with the first pattern noted, that the buzzer aids performance and that immediate buzzer is better than at least one of the other supplementary feedback conditions (11% group).

The short criterion intervals for the 50% and 89% groups generally are associated with better performance than immediate buzzer, but in no case are the differences significant statistically. (In the one analysis in which the 100% group was best, the differences were very small.) Thus, although the results conform to both of the trends noted above, the statistical evidence is not sufficient to reject the idea that all the effects might be attributable to the second trend—that is, that the buzzer aids performance, and that the shorter the criterion interval the better the performance.

A complete analysis was also performed on average duration of contact with the target, under the hypothesis that reinforcing only the longer target contacts would result in more of the longer contacts in relation to the number of shorter ones. This analysis of length of target contacts (Table 9) showed no significant differences for any of the blocks of practice trials, either in the absolute length of hit, or in the gain over the average length of hit on the pretrials (Trials 1-10). Thus, we have no evidence that supplementary feedback will selectively favor the longer contacts with the target.

Table 9

Average Duration of Hits Toward the End of Practice
(in Seconds)

Group	Trials 40-55	Posttrials (Trials 56-60)
100%	.43	.45
89%	.45	.47
50%	.45	.43
11%	.39	.43
0%	.36	.40

[1]The statistical analysis of differences between groups is the Duncan Range Test (15).

LITERATURE CITED

AND

APPENDICES

LITERATURE CITED

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Appendix A

GENERAL INSTRUCTIONS TO SUBJECTS (MEMORIZED BY THE EXPERIMENTER)

"Today you are going to practice skilled movements on the pursuit rotor." (Touch it.) "Have you had experience with this apparatus?" (Wait for no.) "You will try to hold the tip of this stylus on the metal spot as the turntable revolves." (Say this as you demonstrate, then put the stylus in the rack.)

"We study your skill on the pursuit rotor because we want to find out what conditions are most effective for learning various kinds of skilled movements. Of course, skilled movements are important in many Army jobs, as well as in sports and civilian jobs. For example, an infantryman must aim his rifle quickly and accurately. Or a mortar team must set up its weapon quickly, and level it. Many common tasks are somewhat like the pursuit rotor, so similar learning conditions are likely to be effective. The pursuit rotor is not a common task, so a man would not likely have learned it elsewhere. Everyone starts with little skill, so there is great room for improvement.

"Your task, as I said, is to hold the stylus on the target as the turntable revolves. I'll be able to tell how well you're doing, because there's an electrical recorder which operates whenever your stylus tip touches the target.

"You'll find it easier if you hold the stylus between your fingers and thumb, like this, with your thumb along the handle. Your grip should be firm enough to hold the handle, but relaxed. Hold the stylus about level, with the tip resting lightly on the turntable. You'll practice following the moving spot for several trials. First the warning light will come on. Five seconds later the warning light will go out, and the turntable will begin to move as the trial starts. As the turntable moves, try to hold the stylus on the target by making free swinging movements." (Demonstrate.) "Stand back slightly from the table. Don't bend the stylus sharply, like this, and don't touch the metal part of the stylus. You may hold the cord in your other hand to keep it out of the way. The turntable will revolve once every second, in a clockwise direction. After thirty seconds the turntable will stop—and you will rest for twenty-five seconds before the light comes on to signal the start of the next trial. Between the trials, replace the stylus in the rack. Would you please try it." (Hand him the stylus.) "Are you right-handed?" (Wait for reply.)

"After several trials, I'll tell you it's time for a few minutes' rest in another room. Remember, try to hold the stylus on the target as much as you can, whenever the turntable moves.

"Do you have questions?

"Wait for the light which signals the start of the first trial."

Appendix B

SPECIFIC INSTRUCTIONS FOR SUBJECTS IN PARTICULAR GROUPS (MEMORIZED BY THE EXPERIMENTER)

For the 1 (11%), 2 (50%), and 3 (89%) Groups:

"For several trials, I'm going to use a buzzer to help you increase your skill. Your task is basically the same, and the buzzer indicates a good contact with the target.

"You will get the buzzer signal a short time after your stylus touches the moving spot. _____ (1 Many; 2 Some; 3 A few) contacts will not be long enough for you to get the buzzer at all. So the buzzer sound indicates _____ (1 your very long, skillful contacts with moving spot; 2 your fairly long, better-than-average contacts with the moving spot; 3 more than a momentary contact with the spot).

"As you continue practice, I will adjust the buzzer delay according to your increasing skill, so that getting the buzzer will be equally difficult during all stages of training."

For the 100% Group:

"For several trials, I'm going to use a buzzer to help you increase your skill. Your task is basically the same, and the buzzer indicates contact with the target. You will get the buzzer signal as long as your stylus touches the moving spot."

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13. ABSTRACT

An experiment using the pursuit rotor apparatus tested two hypotheses: (a) supplementary feedback aids learning when it provides information by which to distinguish long target contacts from short ones; (b) supplementary feedback, especially if immediate, facilitates performance by providing secondary reinforcement. Five groups, of 20 subjects each, were given 60 trials, with the criterion interval adjusted for every trial to reinforce a particular proportion of target contacts for each group: 100% (immediate buzzer), 89%, 50%, 11%, and 0% (no buzzer). Analysis of covariance indicated that the buzzer significantly improved performance, with the best performance shown by the groups that had an intermediate proportion of the hits reinforced. Information theory would explain some of the results, but would not account for all of the group differences found.

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7 CG FIFTH ARMY FT SHERIDAN ATTN ALFGC TNG
1 CG SIXTH ARMY PRES OF SAN FRAN ATTN AMAAV
1 DIR MEL APG MD
1 CG USA COC EXPERIMENTATION COMD FT ORD
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4 TECH LIB ARMY NATICK LABS NATICK MASS
1 CG USA COC INST OF LAND CBT FT BELVOIR
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ATTN NEUROPSYCHIAT DIV
1 CO HQ ARMY EMLISTED EVAL CTR FT BENJ HARRISON
1 CO USA MOBILITY EQUIP RCD CTR ATTN TECH DOC CTR FT. BELVOIR
1 CO FRANKFORD ARSNL ATTN SMUFA-N6400/202-4
1 4TH ARMY MSL COMD AIR TRANSPORTABLE SAN FRAN
1 REF M MS IS NASA ALA
1 CBT OPNS RES GP COC FT BELVOIR ATTN SN OPRS ANLS HUMAN FACTORS
1 CO ARMY COC ARMOR AGY FT KNOX
1 CO US ARMY COC AVN AGCY FT RUCKER
3 LIB ARMY WAR COLL CARLISLE BKS
2 US MILIT ACAD WEST POINT ATTN LIB
1 COMDT ARMY AVN SCH FT RUCKER ATTN SCH LIB
2 COMDT ARMY SECUR AGY TNG CTR + SCH FT DEVENS ATTN LIB
1 MED FLD SERV SCH BROOKE ARMY MED CTR FT SAM HOUSTON ATTN STIMSON LIB
10 DIR OF INSTR ARMOR SCH FT KNOX
1 COMDT ARMY CHEM CORPS SCH FT MCCLELLAN ATTN EDUC ADV
1 DIR OF INSTR USAIS ATTN AJIIS-D-EPRD FT BENNING
2 COMDT US ARMY SOUTHEASTERN SIG SCH ATTN: EDUC ADVISOR FT GORDON
1 COMDT USA AD SCH FT BLISS
5 ASST COMDT ARMY AIR DEF SCH FT BLISS ATTN CLASSF TECH LIB
10 CG ARMY ARTY + MSL CTR FT SILL ATTN AVN OFFR
1 COMDT ARMED FORCES STAFF COLL NORFOLK
1 COMDT JUDGE ADVOCATE GENERALS SCH U OF VA
1 DPTY COMDT USA AVN SCH ELEMENT GA
1 DPTY ASST COMDT USA AVN SCH ELEMENT GA
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1 EDUC CONSLT ARMY MILIT POLICE SCH FT GORDON
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1 DIR US MIL ACAD WEST POINT
1 SPEC WARFARE SCH LIB FT BRAGG
4 USA SPEC WARFARE SCH ATTN COUNTERINSURGENCY DEPT FT BRAGG
2 SECY US ARMY MSL & MUNITIONS CTR & SCH REDSTONE ARSNL
2 HQ ABERDEEN PG ATTN TECH LIB
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2 DIR BRCD + BN OPNS DEPT USASIS FT BENNING
1 DIR COMM ELEC USAIS FT BENNING
1 DIR ABN-AIR MOBILITY DEPT USAIS FT BENNING
1 CG US ARMY SIGNAL CTR & SCH ATTN SIGOTL-9 (COBET II)
1 SECY OF ARMY, PENTAGON
1 OCS-PERS DA ATTN CHF C+S DIV
1 DIR OF PERS STUDIES + RES ODCSPER DA ATTN BG WALLACE L CLEMENT
2 AGS FOR FORCE DEVEL DA ATTN CHF TNG DIV
1 CG USA MAT COMD ATTN AMCRD-TF
1 US ARMY BEHAVIORAL SCI RES LAB WASH, D.C. ATTN: CRD-AR
1 ARMY PROVOST MARSHAL GEN
1 OFC RESERVE COMPON DA
90 ADMIN DOC ATTN: TCA (HEALY) CAMERON STA ALEX., VA. 22314
1 CO US ARMY MED RES LAB FT KNOX
1 CHF OF R+D DA ATTN CHF TECH + INDSTR LIAISON OFC
1 U S ARMY BEHAVIORAL SCI RES LAB WASH, D.C. ATTN CRD-AIC
1 CO US ARMY MAT COMD WASH D.C. ATTN: AMCPT-CM ROBT DETIENNE
1 PRES ARMY MAINT BD FT KNOX
1 US ARMY ARCTIC TEST CTR R & D OFFICE SEATTLE
2 CG 1ST INF DIV ATTN G3 APO 96345 SAN FRAN
1 CG 3RD INF DIV ATTN G3 NY
3 CG 4TH INF DIV ATTN G3 APO 96262 SAN FRAN
1 CO 7TH INF DIV ATTN G2 APO 96207 SAN FRAN
1 CO 9TH INF DIV (MECH) FT CARSON
3 CG 82D ABN INF DIV FT BRAGG ATTN G3
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